

Advancing our industry through evidence-based research

Research summary overview

Our Research Grant Program actively supports research projects in a variety of fields at universities across Canada. Each research project is linked to at least one of Egg Farmers of Canada's research priorities. Below is an introduction to these research projects as well as their status.

2023 EFC GRANT PROGRAM RESEARCH SUMMARY											
		RESEARCH PRIORITY AREA ADDRES									
PROJECT NAME	STATUS	PAGE	Animal care science	Bird nutrition and health	End of flock management	Environment and sustainability	Food safety	Human nutrition and health	Innovative uses of eggs	Public policy and economics	Research gaps identified by the Code of Practice
Impact of alternative housing systems on layer health and egg production	Complete	6	х	х				Х			
Effect of LED flicker on the welfare, health, and production of pullets reared to 16 weeks and further impacts on hen performance and egg production and quality	Complete	6	х			Х					
Use of 3D kinematics and genomics to evaluate perching biomechanics in commercial and heritage strains of enriched colony housed pullets and laying hens	Complete	7	Х	х							х
The role of omega-3 fatty acids in bone development in pullets: Investigating epigenomic response to breeder and perinatal nutrition	Complete	7	х	Х							



		RESEARCH PRIORITY AREA ADDRESSED										
PROJECT NAME	STATUS	PAGE	Animal care science	Bird nutrition and health	End of flock management	Environment and sustainability	Food safety	Human nutrition and health	Innovative uses of eggs	Public policy and economics	Research gaps identified by the Code of Practice	
Assessment of the impact of Canadian infectious bronchitis virus variants on egg production and fertility in laying hens	Complete	8		х							Х	
Precision feeding layers for improved uniformity, production and sustainability	Complete	8		Х								
How much omega-3 fatty acids do hens require for optimal health and productivity?	Complete	8	Х	Х				x				
Development of strategies for control of avian influenza virus transmission	Complete	9		Х								
The fermentation of end-of-lay hen hydrolysate to produce pathogen-free microbiological-rich plant nutrient solutions	Complete	9			х	х						
A novel non-antibiotic strategy for controlling avian pathogenic <i>Escherichia coli</i> in laying hens	Complete	10					x				х	
Importance of eggshell cuticle quality for reducing bacterial adherence in table eggs	Complete	10					х					
The role of eggs in improving choline and DHA nutrition during development	Complete	11						x				
Impact on metabolic health of new ingredients enriched with active components derived from egg yolk	Complete	11						x	х			
Egg yolk lecithin supplementation to improve pulmonary health: Implications for healthy individuals and individuals with chronic obstructive pulmonary disease	Complete	12						x				
The beneficial effect of egg-derived phosphatidylcholine on the obesity-related immune dysfunction	Complete	12						x				
Egg versus whey protein as the optimal supplement for fitness-conscious people	Complete	13						x	Х			
Understanding the social representations of meat, eggs and animal proteins replacement products and their impact on food habits	Complete	13								Х		
Determination of ideal perch space allowance for pullets	In progress	13	Х								Х	
Assessing hatchery related well-being	In progress	14	х	Х						Х	Х	
The use of pecking blocks as foraging enrichment for improvement of feather condition in enriched colonies	In progress	14	Х								Х	
Pre-hatch sexing for chicks based on chorioallantoic membrane (CAM) immune-interrogation	In progress	14	Х			Х						
Perching requirements for pullets and laying hens: Preferences for grasping and elevation	In progress	14	x								Х	

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PROJECT NAME	STATUS	PAGE	Animal care science	Bird nutrition and health	End of flock management	Environment and sustainability	Food safety	Human nutrition and health	Innovative uses of eggs	Public policy and economics	Research gaps identified by the Code of Practice
Understanding feather pecking in laying hens: The gut-microbiome-brain connection II	In progress	14	Х	Х							
Aggressive and severe feather pecking in brown and white feathered Leghorn pullets: Will blue light during brooding and rearing cycle improve future egg production?	In progress	14	Х			Х					Х
Determination of the metabolic triggers responsible for sexual maturation in laying hens and their relation to rearing environment and nutrition	In progress	15	х	х							Х
Precision pullet rearing strategies for optimal reproductive body condition	In progress	15	Х	х							Х
Optimization of vaccination strategies for laying hens controlling egg production problems induced by currently circulating infectious bronchitis virus variants	In progress	15		х							х
Functional feedstuffs to bolster performance and immunocompetence of pullets reared at different rearing densities in enriched colony housing systems	In progress	15		х							х
Development of novel and alternative approaches using small-RNA based immune-stimulant molecules for control of avian infectious bronchitis virus	In progress	16		Х							
Surveillance of egg yolk peritonitis (EYP) and causative <i>Escherichia coli</i> in Alberta egg farms	In progress	16		х							
Use of full-body imaging scans on live hens to develop a model describing the impact of body composition on sexual maturation	In progress	16		х							Х
Supplementation strategies in vitamin D to protect layers from vitamin D deficiency and immunological stress	In progress	16		х				х			
Evaluation of hemp seed products to ameliorate fatty liver disease and reduce cannibalism in laying hens	In progress	16	Х	х				х			
Manipulation of maturity with light during incubation	In progress	17		Х							
Building a usable surveillance and monitoring tool for avian influenza outbreaks in Canada	In progress	17		Х							
From potential to implementation: Evaluating alternatives to antibiotics in layers through coordinated in vivo experimental studies and barn-level surveillance with industry partners	In progress	17		Х							
Egg residue depletion of oral topical formulations of Fluralaner (Bravecto™) in laying hens	In progress	17	Х	Х			Х				
Antimicrobial peptides: A better alternative to antibiotics on egg farms	In progress	18		х							

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Functional nutrients to support calcium metabolism and egg production in a context of extending laying period in modern hens	In progress	18	Х	Х		Х					
Evaluation of hemp seed products to ameliorate fatty liver disease and reduce cannibalism in laying hens in a modern group housing system and generation of efficacy and safety data	In progress	18	х	х				x			Х
The impact of synchronizing photoperiod with body weight and metabolic thresholds to optimize sexual maturation in cage-free layers	In progress	18	Х	Х							Х
Optimization of environmental and hen welfare outcomes in Canadian egg production using predictive analytics (machine learning) techniques	In progress	19				х					
Sustainable composites from waste eggshells for practical applications	In progress	19				х					
A detailed characterization of particular matter in Canadian egg farms	In progress	19	х	Х		х					
Long-life layers: An environmental, economic, and animal welfare cost/benefit analysis	In progress	19				Х				Х	
Expanding opportunities for Western Canadian fava bean (<i>Vicia faba</i>) as a feedstuff for laying hens	In progress	20		Х		Х					
Towards circular manufacturing strategies for the egg industry using eggshells as value-added mortar filler material for large-scale additive manufacturing	In progress	20				х			х		
Global warming: Impact of cooling strategies on the air quality inside livestock buildings and environmental emissions of gas and bioaerosols	In progress	20	х	х		х	х	x			
Modelling of alternative ventilation designs in layer houses	In progress	20				х					
Cold plasma pasteurization of liquid whole eggs	In progress	20					Х				
Canadian phytobiotics as natural alternatives to antibiotics to control Avian <i>E. coli</i> (APEC)	In progress	20		х			Х				
Developing a vaccine against Avian Pathogenic <i>E. coli</i> (APEC)	In progress	21					Х	x			
Metagenomic Assessment of Risk of <i>Salmonella</i> (MARS): Validation of a rapid diagnostic workflow to support <i>Salmonella</i> control and surveillance program in egg farming	In progress	21				х	х				
Develop new application of egg protein ovotransferrin as a functional food ingredient on bone health	In progress	21						х			
Egg as a strategy to maintain retina health in people with diabetes	In progress	21						x			

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Whole eggs for reducing inflammation and promoting muscle repair in adults with obesity	In progress	21						х			
Role of omega-3 eggs in reducing pro-oxidative and inflammatory effects of omega-6 poly- unsaturated fatty acids (PUFA) in diabetic and geriatric hearts	In progress	21						х			
EGGS-sactly what's required: Eggs as an appealing way to restore nutritional status after cancer treatment	In progress	21						х			
Including egg protein as part of a plant-based dietary pattern improves cardiometabolic health by ameliorating fatty liver disease	In progress	22						х			
A preliminary human study on bioavailability and efficacy of bioactive peptide IRW in egg white hydrolysate	In progress	22						х	х		
Additional daily intake of eggs for improving metabolic outcomes and choline levels in overweight and obese individuals: Phase I study	In progress	22						х			
Modified eggshell membrane formulations as a novel supplement to maintain gut health	In progress	22				х		x	х		
Animal implant studies with nano-textured eggshell-based constructs for bone regeneration	In progress	22						х	х		
From eggshell wastes to key components in green energy storage and conversion	In progress	23							Х		
An integrated process for recovering calcium carbonate and collagen/collagen amino acids from waste shells	In progress	23				х		х	х		
Bioprinting of eggshell membrane-based biomaterials for promotion of would healing	In progress	23				Х		x	Х		
Development of 3D printable self-powered biosensors for glucose monitoring from natural egg white	In progress	23							Х		
Effects of microclimate on the airborne dust concentration in layer houses in Ontario	In progress	23									Х
Phage therapy to decrease <i>E. coli</i> mortality in laying hens	Upcoming	23		Х		Х					
Nutraceuticals for hens and humans through polyphenol enriched feeds and eggs	Upcoming	24		Х				Х			
Valorization of spent hens for a sustainable egg industry	Upcoming	24			Х	Х					
Sustainable and resilient management of egg supply chains using Internet of Things	Upcoming	24			х	Х	х	Х		X	

Completed research 2022-2023



Animal care science

Impact of alternative housing systems on layer health and egg production

Dr. Martine Boulianne, Université de Montréal

Also covers: Bird nutrition and health, human nutrition and health.

Objective

Data was collected from commercial farms to understand the effect of enriched colony and aviary housing environments on laying hen health and welfare, air and litter quality and production parameters such as egg production, feed consumption and mortality.

Results

This comprehensive study showed no differences in performance and egg quality between enriched colony and aviary housing environments. However, aviary housing negatively affected air quality and bioaerosols (dust, endotoxins and bacteria), mortality rate, the prevalence of keel bone fractures, footpad dermatitis, coccidiosis and the number of pathogenic *Clostridium* *perfringens* strains. The researcher also found the presence of *Eimeria* spp eggs (the parasite causing coccidiosis) in both housing systems, which suggests that mitigation strategies should be taken into consideration.

Effect of LED flicker on the welfare, health, and production of pullets reared to 16 weeks and further impacts on hen performance and egg production and quality

Dr. Karen Schwean-Lardner, University of Saskatchewan

Also covers: Environment and sustainability.

Objective

This longitudinal study determined the impact of flickering LED lights on pullet and laying hen health, welfare, and performance including egg production and egg quality.

Results

For this study, three levels of flicker were assessed, visible, not visible to humans but visible to birds and non-visible. It was found that the two flickers visible to birds had minimal but negative effects on the behaviour, fear and stress of pullets. In addition, it was observed that humans found the visible flicker aversive when working with the pullets. All effects on birds or humans dissipated once the birds were moved into a laying facility with no flickering lights.

In summary, the researcher found no negative effects of raising pullets under flickering lights. However, future studies should test the effect of flickering LED lights during the laying period.

Use of 3D kinematics and genomics to evaluate perching biomechanics in commercial and heritage strains of enriched colony housed pullets and laying hens

Dr. Clover Bench, University of Alberta

Also covers: Bird nutrition and health, research gaps identified by the Code of Practice.

Objective

This study assessed the biomechanics of perching behaviour in pullets and laying hens using 3D kinematics to determine optimal phenotypes associated with specific genomic markers, stronger bones and better keel and foot health for hens housed in enriched colony systems.

Results

The study found that mushroom-shaped perches are preferable to round perches for laying hens housed in enriched colonies due to increase stability while perching and reduce keel bone damage. Lower incidence of keel bone damage in smaller white-strains of birds, despite lower bone mineralization, indicate that these birds might be more readily suited for enriched colony housing in comparison to larger brown-strain birds. However, this might be due to a body size/weight effect. A number of promising candidate genes associated to bone health were identified.



Bird nutrition and health

The role of omega-3 fatty acids in bone development in pullets: Investigating epigenomic response to breeder and perinatal nutrition

Dr. Elijah Kiarie, University of Guelph

Also covers: Animal care science.

Objective

This project investigated the epigenetic (changes in gene expression), long-term effects of feeding breeder hens a diet enriched with omega-3 fatty acids (n-3 PUFA) on embryonic bone development. It also assessed the subsequent effect on skeletal development and performance in breeder offspring, namely pullets and laying hens, and on pullet behaviour when subjected to stressors.

Results

The research findings confirmed that hatching eggs can be enriched with n-3 PUFA, by feeding ISA Brown and Shaver white breeders an omega-3 rich diet. Chicks hatched from n-3 PUFA enriched eggs showed aversion to isolation, with increased vocalizations. No other effects were observed in the chicks, and those male chicks raised to adulthood showed no detrimental effect of n-3 PUFA supplementation on sexual behaviour or fertility. Feeding n-3 PUFA to both Shaver white breeders and its progeny, rather than just one of them, produced the strongest tibias at 18 weeks of age; however, only those on the DHA treatment showed an increase in femur ash weight. Still, no residual effects of skeletal differences or immunocompetence were observed by 42 weeks of age in either of the strains.



Assessment of the impact of Canadian infectious bronchitis virus variants on egg production and fertility in laying hens

Dr. Faizal Careem, University of Calgary

Objective

The study sought to determine the economic impact of major infectious bronchitis virus (IBV) strains that lead to egg production and quality problems in laying hens in Canada. This project also aimed to propose mitigation strategies against IBV and to evaluate vaccine capability of protecting laying hens.

Results

Out of almost 100 samples received from Ontario and Alberta, most of the isolates were identified as one of four variants (strains), DMV1639, 4/91, Massachusetts and Cal1737/04, with DMV1639 and 4/91 involving recombination with IBV vaccine strains. Of these four variants, the 4/91 variant was the only one not to reduce egg production. At the same time, DMV1639 was found to be a highly pathogenic strain, causing a 20 to 60% reduction in egg production and producing cysts leading to false layer syndrome. Given the large impact on egg production (40% reduction average), a cost-benefit analysis of five different scenarios shows a high benefit of vaccination against IBV.

Overall, the research results confirm that the maintenance of high biosecurity is essential to avoid the recombination of wild variants and vaccine strains. It also suggests that the use of vaccines could be a cost-effective strategy against IBV infections.

Precision feeding layers for improved uniformity, production and sustainability Dr. Martin Zuidhof, University of Alberta

Objective

The project evaluated the use of precision feeding to improve the uniformity of free run pullets and laying hens by feeding an optimal diet based on real-time body weight readings and reducing body size and frame size variation at the point of sexual maturity.

Results

The researchers found that the current practice of providing continuous access to feed resulted in the best hen performance with greater feed intake, deposition of abdominal fat, egg production and egg mass, while precision feeding produced greater flock uniformity and eggs with larger egg yolks. When comparing dietary energy, the researchers found that while a high energy diet (3,000 kcal/kg) produced more eggs, hens laid smaller eggs, and the opposite was true for a low energy diet (2,600 kcal/kg), with the best results obtained in the intermediate diet (2,800 kcal/kg). These conclusions were further supported by a partial economic analysis (feed costs versus egg revenue), which indicated that a standard energy, non-precision feeding regimen had the greatest margin over feed cost per bird. While the research results support the maintenance of the standard feeding practices for laying hens, the researchers suggested that increasing dietary metabolizable energy during the pullet phase may encourage adipose tissue deposition prior sexual maturation to allow for a smooth transition into lay.

How much omega-3 fatty acids do hens require for optimal health and productivity? *Dr. James House, University of Manitoba*

Also covers: Animal care science, human nutrition

Also covers: Animal care science, human nutrition and health.

Objective

This project sought to define omega-3 requirements for optimal health and performance in pullets and laying hens. To do this, the study aimed to identify whether the type and level of the omega-3 fatty acids in the diet affect bird health and productivity. Additionally, it looked to determine the optimal quantity and type of omega-3 fatty acids to enhance immunity in pullets and laying hens.

Results

The inclusion of flaxseed oil in hens diets, contributed to the accumulation of alpha-linolenic acid (ALA) in tissues and plasma, while dietary algae supplementation resulted in more eicosapentaenoic acid (EPA) and docohexaenoic acid (DHA) deposition in tissues and plasma. In addition, algae was more effective at producing anti-inflammatory products than flaxseed. Data suggested that a dietary supplementation of 2.5% fish oil (EPA enriched) suffices to increase the n-3:n-6 PUFA ratio in tissues and plasma. Using yolk DHA as a marker, the researcher concluded that a dietary level of 0.4% ALA is the minimum required to ensure maximal DHA levels in tissues and support immunity.

Overall, this project suggests that dietary omega-3 fatty acids have potential immunomodulatory effects both in pullets and laying hens and dietary requirements should be established.



Development of strategies for control of avian influenza virus transmission

Dr. Shayan Sharif, University of Guelph

Objective

This project sought to find avian influenza's transmission routes and the relative impact of each route, and determine the efficacy of Toll-like receptor (TLR) ligands, proteins that help recognize microbes, as stand alone anti-viral molecules to reduce the transmission of avian influenza or as adjuvants in vaccines.

Results

The study found that avian influenza can be transmitted via direct contact, which includes the aerosol and fecal routes in chickens. The researcher also found that TLR ligands can be used as immunomodulatory agents against avian influenza. However, although vaccines that include TLR ligands can successfully reduce the spread of avian influenza by reducing shedding, but they do not completely stop it. Thus, additional measures and strategies for the control of avian influenza are needed.

End of flock management

The fermentation of end-of-lay hen hydrolysate to produce pathogen-free microbiological-rich plant nutrient solutions *Mr. Marc Legault, Alberta Agriculture and Forestry*

Also covers: Environment and sustainability.

Objective

This study looked to demonstrate the value-added potential for hens at the end of their production cycle by fermenting hydrolysate from end-of-lay hens to produce an organic plant nutrient solution. Researchers aimed to grow crops using this solution under commercial greenhouse conditions where crop productivity and soil health would be investigated.

Results

End-of-lay hen hydrolysate can be divided into a top fat layer, a protein-rich middle layer and a mineral bottom layer. The researcher found great potential for bio-methane production from the hydrolysate, particularly from the fat-rich layer. When fermented, defatted end-of-lay hen hydrolysate was tested, it produced moderate results under greenhouse conditions, but in some cases, it produced 50% more yield than synthetic fertilizer. Likewise, spray dried end-of-lay hen hydrolysate can be used for animal feed formulations. Broader crop field applications could be another application.

Altogether, this project demonstrated that there are numerous value-added applications for end-of-lay hen hydrolysate if the necessary infrastructure is in place.

Food safety

A novel non-antibiotic strategy for controlling avian pathogenic *Escherichia coli* in laying hens *Dr. Dongyan Niu, University of Calgary*

Also covers: Research gaps identified by the Code of Practice.

Objective

This study evaluated the impact of plant tannins (a class of astringent) and bacteriophages (viruses that attack bacteria) to optimize the control of *Escherichia coli* in free run housing systems in lieu of using antibiotics.

Results

The project identified a bacteriophage with great potential for biocontrol of avian pathogenic *E. coli* in laying hens, and a phage-cocktail was developed to be delivered via the drinking water. The researcher confirmed that tannins collected from seaweed and purple prairie clover also have anti-avian pathogenic *E. coli* activity, which suggests that they should be further studied. The results from this study suggest that alternatives to antibiotics can be identified for the treatment of avian pathogenic *E. coli*.



Importance of eggshell cuticle quality for reducing bacterial adherence in table eggs

Dr. Maxwell Hincke, University of Ottawa

Objective

This project aimed to identify the effect of housing system, hen age and egg washing on eggshell quality and components of the eggshell cuticle. The study also looked at bacterial load and adhesion of eggs.

Results

The study found that eggs from free run systems had more cuticle plug thickness and pore length, and a lower eggshell bacterial load than those from conventional housing and enriched colony systems. Also, alternative housing was associated with a higher total cuticle compared to conventional housing. When egg processing was evaluated, they found that eggs washed with a bleach solution had lower egg cuticle coverage than ungraded eggs, and that unwashed eggs tended to have a lower bacterial load than washed ones. Eggshell bacteria was concentrated near the cracks and fissures of unwashed eggs. Finally, some active components of the cuticle were identified as potential targets for flock selection against eggshell bacterial adhesion.

The study showed that housing system has an effect on cuticle quality and thereby impacts on food safety. The findings supported the importance of cuticle constituents in reducing eggshell bacterial load.



Human nutrition and health

The role of eggs in improving choline and DHA nutrition during development

Dr. Angela Devlin, University of British Columbia

Objective

This project sought to understand the role of eggs on child development. Specifically, it explored if a mother's egg consumption during lactation affects the nutrient composition of human milk, and the impact egg consumption has on dietary nutrient intake in children. This study also investigated the cardiometabolic risk of egg consumption in women and children.

Results

Egg consumption in lactating women did not increase choline or DHA in breastmilk; however, it did increase betaine levels, a product of choline metabolism important for hydration and in cases of folic acid deficiency. When young children were studied, Dr. Devlin found that average egg consumption per week increased from two eggs at the age of 1, to five eggs by the age of 6. Egg consumption in young children increased blood levels of choline, DHA, vitamin D and products of choline metabolism, and helped children meet the daily recommendations for choline and DHA.

Impact on metabolic health of new ingredients enriched with active components derived from egg yolk

Dr. Alain Doyen, Université Laval

Also covers: Innovative uses of eggs.

Objective

When an egg yolk is centrifuged, it separates into two fractions: a liquid fraction, or plasma, and a solid fraction, or granules. This project aimed to produce and characterize fractions (granules and plasma) generated from control and high hydrostatic pressuretreated egg yolk, to evaluate the digestibility of egg yolk and granule fractions, and to assess the impact of these new ingredients on microbiome and gut health.

Results

The results of the project support that egg yolk or egg yolk granules consumption limits weight gain and protects against glucose-metabolism disorders. In addition, while some fat accumulation was observed in the liver when egg yolks were consumed, this effect was absent when egg yolk granules were consumed instead. The project also tested the effect of applying pressure and temperature to extract bioactive



components from the yolk and granules. Little success was found; however, the researchers found that by applying pressure, the digestibility of the granule fraction improved, increasing the chances for absorption of bioactive components during the digestion process.

Egg yolk lecithin supplementation to improve pulmonary health: Implications for healthy individuals and individuals with chronic obstructive pulmonary disease

Dr. Mathieu Morissette, Institut universitaire de cardiologie et de pneumologie de Québec – Université Laval

Objective

A diet deficient in methionine and choline can have severe metabolic effects including altered lung function, like that observed in long-time smokers with chronic obstructive pulmonary disease (COPD) and reduced hepatic function and lipid circulating levels. This study aimed to investigate the impact of egg yolk lecithin supplementation on pulmonary health, circulating phosphatidylcholine levels and lung function in healthy individuals and individuals with COPD, using a mice model.

Results

Egg yolk lecithin failed to rescue pulmonary function. However, mice on the egg yolk lecithin diet showed a complete recovery of normal circulating lipids levels (phosphatidylcholine, and HDL, non-HDL and total cholesterol). Similarly, the egg yolk lecithin diet alleviated hepatic inflammation and reversed hepatic damage. These results suggest that a dietary supplementation with egg yolk lecithin could help people suffering from liver diseases.

The beneficial effect of egg-derived phosphatidylcholine on the obesity-related immune dysfunction

Dr. Caroline Richard, University of Alberta

Objective

Eggs are a source of phosphatidylcholine, a type of fat that is the major component of cell membranes that has been found to have a positive effect on immune function in humans. This project aimed to understand the direct and indirect mechanisms by which eggphosphatidylcholine can counteract the negative effects of a high-fat diet and obesity on the function of T-cells (cells that play a role in immune response).

Results

Mice on a high-fat diet showed a reduction of the intestinal barrier function, an important immunity barrier that prevents infections entering through the intestine. The researcher found that supplementation with egg phosphatidylcholine when subjects are on a high-fat diet, improved the intestinal barrier function and immune response (T-cell function). Although the other source of phosphatidylcholine (soy) also produced similar results, it is important to note that eggs are a much richer source of phosphatidylcholine. Given that choline is an essential nutrient that is under consumed, increasing egg consumption is the most effective way to improve immune function under high-fat dietary conditions.

Innovative uses of eggs

Egg versus whey protein as the optimal supplement for fitness-conscious people *Dr. Philip Chilibeck, University of Saskatchewan*

Also covers: Human nutrition and health.

Objective

This study evaluated the effectiveness of whole egg protein powder supplements compared to whey protein supplements in the diets of males and females aged 18-35 years old who are currently engaged in exercise training.

Results

After 12 weeks of resistance training, all the participants showed an increase in strength, muscle and decrease in fat tissue. However, those on whole egg supplement increased muscle mass by 1.6 kg in average as compared to those using whey supplements or placebo, which only increased by 0.8 kg. Likewise, participants on the whole egg supplement had greater reduction in body fat. Finally, although the gain in strength was similar among groups, those in the whole egg supplement showed a higher increase in bench press strength (chest press). The study shows that a whole egg supplement is superior to other supplements during resistance training.



Public policy and economics

Understanding the social representations of meat, eggs and protein replacement products and their impact on food habits *Dr. Laurence Godin, Université Laval*

Objective

The researchers intended to understand the role and social representations of alternatives to meat, eggs, and other animal proteins. This project provides the egg industry with knowledge on emerging dietary trends that might impact on egg consumption practices.

Results

The study found that social media actors promoting the consumption of alternative proteins tend to choose one of the three following aspects for their publications: (1) animal wellbeing and the environment, (2) nutrition and health, and (3) daily consumption practices (e.g. food planning, recipes, etc.). However, the researchers found that, in general, how well this content was received depended on the beliefs of the audience.

Research in progress

Animal care science

Determination of ideal perch space allowance for pullets

Dr. Karen Schwean-Lardner, University of Saskatchewan

Also covers: Research gaps identified by the Code of Practice.

Objective

This study will determine the minimum perch space requirements for pullets throughout rearing. Additionally, this project aims to determine the impact of perch space and genotype on growth and performance parameters, behaviour, bone strength and keel bone damage.

Assessing hatchery related well-being

Dr. Karen Schwean-Lardner, University of Saskatchewan

Also covers: Bird nutrition and health, public policy and economics, research gaps identified by the Code of Practice.

Objective

The researchers look to provide evidence-based information to assist hatcheries with decision-making around equipment and transportation practices that promote chick welfare.

The use of pecking blocks as foraging enrichment for improvement of feather condition in enriched colonies

Dr. Tina Widowski, University of Guelph

Also covers: Research gaps identified by the Code of Practice.

Objective

This project looks to determine the effect of pecking blocks on foraging behaviour, feather pecking, feather damage and beak shape, while also identifying the most effective placement of pecking blocks within an enriched colony housing system. The researchers will also note individual differences in frequency and duration of pecking block use among hens and will match this behaviour to health outcomes, including keel fractures, feather damage and eggshell quality. Finally, this study will establish whether the attraction to pecking blocks is related to its nutritional composition.

Pre-hatch sexing for chicks based on chorioallantoic membrane (CAM) immune-interrogation

Dr. Maxwell Hincke, University of Ottawa

Also covers: Environment and sustainability.

This research project is currently underway and an update will be provided in a future research summary.

Perching requirements for pullets and laying hens: Preferences for grasping and elevation

Dr. Tina Widowski, University of Guelph

Also covers: Research gaps identified by the Code of Practice.

Objective

There are different understandings about what structures can be used as perches for laying hens, particularly in structures where hens cannot wrap their toes around the structure. To provide greater context to perching requirements, this study aims to explore hens' motivation for grasping and elevation, as well as how motivation for perching develops in pullets and if health conditions in older birds affects their roosting preferences. Additionally, the researchers will determine if strain differences affect these preferences.

Understanding feather pecking in laying hens: The gut-microbiome-brain connection II

Dr. Alexandra Harlander, University of Guelph

Also covers: Bird nutrition and health.

Objective

The researchers seek to identify a simple, practical prebiotic nutraceutical that can prevent or reduce feather pecking in laying hens on Canadian farms. To do this, they will use a galacto-oligosaccharide prebiotic and investigate its efficacy, effectiveness, and its potential mode of action.

Aggressive and severe feather pecking in brown and white feathered Leghorn pullets: Will blue light during brooding and rearing cycle improve future egg production?

Dr. Karen Schwean-Lardner, University of Saskatchewan

Also covers: Environment and sustainability, research gaps identified by the Code of Practice.

Objective

Aggressive feather pecking and cannibalism are significant issues affecting animal welfare and production on egg farms. This study will determine whether the use of blue light alters behaviour in brown and white feathered Leghorn pullets, resulting in reductions in aggressive pecking compared to birds reared under white light. In addition, the researchers will assess if using blue light during the brooding and rearing period close to the age of sexual maturation has a lingering effect on egg production when birds transition to white light at either 15 or 17 weeks of age.



Bird nutrition and health

Determination of the metabolic triggers responsible for sexual maturation in laying hens and their relation to rearing environment and nutrition

Dr. Gregoy Bedecarrats, University of Guelph

Also covers: Animal care science, research gaps identified by the Code of Practice.

Objective

This study aims to determine the body weight and body composition thresholds responsible for initiating sexual maturation in two strains of laying hens reared in different environments. The researchers will characterize the metabolic signals responsible for activating and inhibiting the reproductive axis and determine if this is impacted by different rearing environments, and if this impacts skeletal integrity.

Precision pullet rearing strategies for optimal reproductive body condition

Dr. Martin Zuidhof, University of Alberta

Also covers: Animal care science, research gaps identified by the Code of Practice.

Objective

This project aims to optimize nutritional management for free run pullets and hens. The researchers will strive to understand the metabolic and physiological interactions that govern sexual maturation and lifetime egg production using precision feeding.

Optimization of vaccination strategies for laying hens controlling egg production problems induced by currently circulating infectious bronchitis virus variants

Dr. Faizal Careem, University of Calgary

Also covers: Research gaps identified by the Code of Practice.

Objective

This project seeks to optimize vaccination strategies against false layer syndrome, shell-less egg syndrome and other egg production abnormalities induced by select IBV variants isolated from laying hens. To do this, the researcher will test hens raised in Eastern and Western Canada using currently available IBV vaccines in Canada.

Functional feedstuffs to bolster performance and immunocompetence of pullets reared at different rearing densities in enriched colony housing systems

Dr. Elijah Kiarie, University of Guelph

Also covers: Research gaps identified by the Code of Practice.

Objective

This study aims to understand the impact of functional feedstuffs (e.g. omega-3 fatty acids, yeast metabolites) on pullet growth, mortality, health and *E. coli* load in

enriched colony housing systems at low and high stocking densities. Additionally, this project will examine the long-term effects of functional feedstuffs on laying hen performance and livability.

Development of novel and alternative approaches using small-RNA based immunestimulant molecules for control of avian infectious bronchitis virus

Dr. Faizal Careem, University of Calgary

This research project is currently underway and an update will be provided in a future research summary.

Surveillance of egg yolk peritonitis (EYP) and causative *Escherichia coli* in Alberta egg farms

Dr. Dongyan Niu, University of Calgary

Objective

This study will determine the prevalence and impact of EYP in Alberta pullets and laying hens. Additionally, the researchers aim to genetically characterize EYP and determine risk factors associated with its existence.

Use of full-body imaging scans on live hens to develop a model describing the impact of body composition on sexual maturation

Dr. Gregoy Bedecarrats, University of Guelph

Also covers: Research gaps identified by the Code of Practice.

Objective

This project seeks to develop a standard operating procedure for using full-body imaging scans on live hens and monitor body composition changes during growth of pullets with a specific focus on adipose tissue accumulation and bone characteristics. The researchers will also determine the precise relationship between changes in body composition and the onset of sexual maturation throughout the development of pullets and will generate a model describing the physiological processes governing the impact of body composition on reproductive capacity and fitness. This model will provide the tools to predict growth and maturation of pullets and proactively implement on-farm adjustments to ensure nutrition and housing requirements are met during pullet growth.

Supplementation strategies in vitamin D to protect layers from vitamin D deficiency and immunological stress

Dr. Marie-Pierre Létourneau-Montminy, Université Laval

Also covers: Human nutrition and health.

Objective

This study will test the addition of vitamin D to hen diets in a more active form, to the maximum allowed, for up to 90 weeks of laying. Researchers will specifically explore the impact of this diet on production performance, mineral levels, immune system, and bone health. With this project, the researchers look to improve the robustness of laying hens so that they can better cope with nutritional, immune, and environmental stresses in a context of longer laying cycles.

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Evaluation of hemp seed products to ameliorate fatty liver disease and reduce cannibalism in laying hens

Dr. Stephanie Collins, Dalhousie University

Also covers: Animal care science, human nutrition and health.

Objective

This study will look at the effect of feeding hemp by-products to laying hens, specifically assessing the impact on production performance, mortality rate, incidence of fatty liver disease, egg yolk cannabidiol (CBD) and fatty acid profile, feather pecking behaviour and incidence of cannibalism, and gut microbial populations. The researcher aims to provide recommendations for including hemp products in laying hen diets.

Manipulation of maturity with light during incubation

Dr. Bruce Rathgeber, Dalhousie University

Objective

The researchers will determine the impact of photoperiod length during incubation of hatching eggs on several factors, including: Hatch success and timing of hatch, early post-placement feed and water intake, recovery from long distance transportation, age at first egg, overall performance over a production period, egg number and egg size, and bone health in the long term. This project will provide data to further the knowledge of potential benefits of using lights in incubators.

Building a usable surveillance and monitoring tool for avian influenza outbreaks in Canada

Dr. Rozita Dara, University of Guelph

This research project is currently underway and an update will be provided in a future research summary.

From potential to implementation: Evaluating alternatives to antibiotics in layers through coordinated in vivo experimental studies and barn-level surveillance with industry partners

Dr. Nicole Ricker, University of Guelph

Objective

For this project, the researchers will identify changes in cecal microbiota short-chain fatty acid production (e.g. lactate) in response to acidification administered through either feed or water additives, as well as noting biomarkers or easy-to-measure physiological indicators that could confirm the success of the acidification treatment. The researchers will then partner with industry to observe and validate, at the barn level, the use of biomarkers and the effectiveness of water acidification and protected feed acidifier on avian pathogenic *E. coli* shedding and colonization.



Egg residue depletion of oral topical formulations of Fluralaner (Bravecto[™]) in laying hens

Dr. Patricia Dowling, University of Saskatchewan

Also covers: Animal care science, food safety.

Objective

Canadian small flocks lack affordable and convenient treatment options against one of the most significant ectoparasite pest in poultry, the red mite. This project will determine if canine or feline formulations of Fluralaner, given orally or applied topically, respectively, would have similar residue depletion in eggs as the soon-to-be-approved poultry formulation Exholt[™] and, therefore, would be suitable for small flock use to treat and control red mites.



Antimicrobial peptides: A better alternative to antibiotics on egg farms

Dr. Inanc Birol, Michael Smith Genome Science Centre

This research project is currently underway and an update will be provided in a future research summary.

Functional nutrients to support calcium metabolism and egg production in a context of extending laying period in modern hens

Dr. Angel René Alfonso Avila, Centre de recherche en sciences animales de Deschambault (CRSAD)

Also covers: Animal care science, environment and sustainability.

Objective

Over the decades, the assessment of nutrients such as vitamin K and magnesium requirements has not evolved with those of amino acids or calcium. The researchers in this project look to determine the impact of functional nutrients on calcium metabolism and egg production, particularly in long-life layers. Evaluation of hemp seed products to ameliorate fatty liver disease and reduce cannibalism in laying hens in a modern group housing system and generation of efficacy and safety data

Dr. Stephanie Collins, Dalhousie University

Also covers: Animal care science, human nutrition and health, research gaps identified by the Code of Practice.

Objective

This project will be the continuation of a currently ongoing project, and aims to expand on the findings of feeding hemp by-products to laying hens by including colony housing in the project and brown hens housed in a free run housing system.

The impact of synchronizing photoperiod with body weight and metabolic thresholds to optimize sexual maturation in cage-free layers

Dr. Gregoy Bedecarrats, University of Guelph

Also covers: Animal care science, research gaps identified by the Code of Practice.

Objective

The researchers want to identify the relationship between metabolic and photoperiodic (light) cues in laying hens and determine the minimum thresholds to achieve optimal entry into lay. In addition, they will establish the influence of free run environments on activity levels and its impact on body composition and bone quality as it relates to the timing of sexual maturation in laying hens.

Environment and sustainability

Optimization of environmental and hen welfare outcomes in Canadian egg production using predictive analytics (machine learning) techniques

Dr. Nathan Pelletier, University of British Columbia – Okanagan

Objective

The researchers are aiming to optimize the sustainability of the egg industry by identifying animal welfare and environmental best practices through machine learning techniques. The results from this project will provide improvement opportunities and trade-offs to inform the ongoing housing system transition in Canada.



Sustainable composites from waste eggshells for practical applications

Dr. Duncan Cree, University of Saskatchewan

This research project is currently underway and an update will be provided in a future research summary.

A detailed characterization of particular matter in Canadian egg farms

Dr. Ran Zhao, University of Alberta

Also covers: Animal care science, bird nutrition and health.

Objective

This study seeks to evaluate, optimize and validate the use of low-cost air quality sensors in egg farms. Additionally, the researchers aim to understand the trend of dust and particulate matter in Canadian egg farms, particularly those with enriched colony and aviary housing systems. This includes identifying factors impinging on the concentration of dust and particulate matter and understanding the chemical composition and toxicological effect of particulate matter on egg farms.

Long-life layers: An environmental, economic, and animal welfare cost/benefit analysis

Dr. Nathan Pelletier, University of British Columbia – Okanagan

Also covers: Public policy and economics.

Objective

This study will investigate and quantify the potential effects of extending lay cycle lengths on the environmental, animal welfare and economic performance of egg production in Canada. The evaluation of these impacts can provide valuable information to Canada's egg farmers about the economic feasibility and sustainability implications of longer lay cycles.

Expanding opportunities for Western Canadian fava bean (*Vicia faba*) as a feedstuff for laying hens

Dr. Doug Korver, University of Alberta

Also covers: Bird nutrition and health.

Objective

This project seeks to understand the nutritional characteristics of Canadian fava beans and incorporate them into feeding programs for laying hens in a way that minimizes impacts on productivity and bird health.

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Towards circular manufacturing strategies for the egg industry using eggshells as valueadded mortar filler material for large-scale additive manufacturing

Dr. Lucas Hof, École de technologie supérieure

Also covers: Innovative uses of eggs.

This research project is currently underway and an update will be provided in a future research summary.

Global warming: Impact of cooling strategies on the air quality inside livestock buildings and environmental emissions of gas and bioaerosols

Dr. Stéphane Godbout, Research and Development institute for the agri-environment (IRDA)

Also covers: Animal care science, bird nutrition and health, food safety, human nutrition and health.

Objective

Global warming and the increase frequency of heat waves might promote the use of water-based cooling systems. However, little is known about the health risk associated. This study will investigate the effects on air quality of an experimental evaporative cooling pad system, with a focus on gas and bioaerosols emissions, and on water condition and biofilms presence in the cooling pad.

Modelling of alternative ventilation designs in layer houses

Dr. Syeda Tasnim, University of Guelph

Objective

This project aims to develop and implement simulation mathematical models to evaluate the performance of conventional and alternative ventilation designs for layer houses in Ontario.



Food safety

Cold plasma pasteurization of liquid whole eggs Dr. Kevin Keener, University of Guelph

This research project is currently underway and an update will be provided in a future research summary.

Canadian phytobiotics as natural alternatives to antibiotics to control Avian *E. Coli* (APEC)

Dr. Sophie Kernéis-Golsteyn, Lethbridge College

Also covers: Bird nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

Developing a vaccine against Avian Pathogenic *E. Coli* (APEC)

Dr. Aaron White, VIDO, University of Saskatchewan

Also covers: Human nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

Metagenomic Assessment of Risk of Salmonella (MARS): Validation of a rapid diagnostic workflow to support Salmonella control and surveillance program in egg farming

Dr. Anatoliy Trokhymchuk, Prairie Diagnostic Services, University of Saskatchewan

Also covers: Environment and sustainability.

Objective

This project seeks to develop and validate a rapid metagenomics-based workflow to support *Salmonella* detection, characterization, risk profiling, and surveillance in egg production systems.

Human nutrition and health

Develop new application of egg protein ovotransferrin as a functional food ingredient for bone health

Dr. Jianping Wu, University of Alberta

This research project is currently underway and an update will be provided in a future research summary.

Eggs as a strategy to maintain retina health in people with diabetes

Dr. Miyoung Suh, University of Manitoba

Objective

This project will investigate the effects of consuming lutein and omega-3 DHA-enriched eggs on retina health in people with diabetes. The results of this study will contribute to the development of prevention strategies for eye health in diabetic individuals.

Whole eggs for reducing inflammation and promoting muscle repair in adults with obesity

Dr. Michael De Lisio, University of Ottawa

Objective

This project seeks to understand if a short-term increase in whole egg consumption aids in muscle regeneration and reduces inflammation following exercise in obese adults.

Role of omega-3 eggs in reducing pro-oxidative and inflammatory effects of omega-6 polyunsaturated fatty acids (PUFA) in diabetic and geriatric hearts

Dr. Sanjoy Ghosh, University of British Columbia – Okanagan

Objective

Cardiovascular disease is the leading cause of morbidity and mortality in both older and diabetic patients, due to the loss of antioxidants such as glutathione (GSH). The researchers aim to determine whether regular whole eggs or omega-3 PUFA enriched eggs can improve cardiac GSH, elevate circulating omega-3 PUFA levels and attenuate both inflammation and oxidative stress.

EGGS-actly what's required: Eggs as an appealing way to restore nutritional status after cancer treatment

Dr. Vera Mazurak, University of Alberta

Objective

This project will use an egg-based diet to promote adequate intake of high-quality protein, maintain weight and muscle mass, enhance immune function and improve food related quality of life for people who have received chemotherapy treatment.

Including egg protein as part of a plant-based dietary pattern improves cardiometabolic health by ameliorating fatty liver disease

Dr. Carla Taylor, University of Manitoba

Objective

People with excessive accumulation of fat in liver cells frequently develop type 2 diabetes, cardiovascular disease and liver cancer. The researchers will use several high protein diets containing whole egg protein or egg white protein, individually or in combination with plant-based protein and compare these to a plant-based protein diet alone. They will examine the effects of these diets on liver fat accumulation, adipose tissue, insulin resistance, blood pressure and gut microbiome of a rodent model of fatty liver and cardiometabolic disease.



A preliminary human study on bioavailability and efficacy of bioactive peptide IRW in egg white hydrolysate

Dr. Jianping Wu, University of Alberta

Also covers: Innovative uses of eggs.

Objective

IRW is a bioactive peptide present in eggs that has shown potential health effects against hypertension, type 2 diabetes, insulin resistance, oxidation, and inflammation. However, its bioavailability and efficacy in humans has yet to be studied. Here, the researchers seek to perform a preliminary human study to test the bioavailability and efficacy of IRW in egg white hydrolysate in lowering blood pressure and blood glucose.

Additional daily intake of eggs for improving metabolic outcomes and choline levels in overweight and obese individuals: Phase I study Dr. Clara Cho, University of Guelph

Objective

This study aspires to determine the effect of additional daily intake of eggs on a variety of metabolic indices (e.g. liver, fat, glucose levels, body mass, etc.) and choline and related metabolites, including markers of disease, in overweight and obese individuals.

Innovative uses of eggs

Modified eggshell membrane formulations as a novel supplement to maintain gut health

Dr. Maxwell Hincke, University of Ottawa

Also covers: Human nutrition and health, environment and sustainability.

This research project is currently underway and an update will be provided in a future research summary.

Animal implant studies with nano-textured eggshell-based constructs for bone regeneration

Dr. Maxwell Hincke, University of Ottawa

Also covers: Human nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

From eggshell wastes to key components in green energy storage and conversion

Dr. Zhi Li, University of Alberta

This research project is currently underway and an update will be provided in a future research summary.

An integrated process for recovering calcium carbonate and collagen/collagen amino acids from waste shells

Dr. Duncan Cree, University of Saskatchewan

Also covers: Environment and sustainability, human nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

Bioprinting of eggshell membrane-based biomaterials for promotion of wound healing

Dr. Maxwell Hincke, University of Ottawa

Also covers: Environment and sustainability, human nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

Development of 3D printable self-powered biosensors for glucose monitoring from natural egg white

Dr. Wen Zhong, University of Manitoba

This research project is currently underway and an update will be provided in a future research summary.



Research gaps identified by the Code of Practice

Effects of microclimate on the airborne dust concentration in layer houses in Ontario

Dr. Syeda Tasnim, University of Guelph

Objective

This project will characterize the microclimate of layer houses in Ontario, with emphasis on understanding its effect on the concentration of airborne dust.

Upcoming research projects

Bird nutrition and health

Phage therapy to decrease *E. coli* mortality in laying hens

Dr. Martine Boulianne, Université de Montréal

Also covers: Environment and sustainability.

This research project is currently underway and an update will be provided in a future research summary.



Nutraceuticals for hens and humans through polyphenol-enriched feeds and eggs

Dr. Deborah Adewole, University of Saskatchewan

Also covers: Human nutrition and health.

Objective

This project will determine if feeding hens a polyphenolrich diet can result in polyphenol-enriched eggs, and the effects on egg shelf life, egg taste, hens health, and environmental emissions.

End of flock management

Valorization of spent hens for a sustainable egg industry

Dr. Jianping Wu, University of Alberta

Also covers: Environment and sustainability.

Objective

This project seeks to develop an industry viable approach of valorization of spent hens with demonstrated financial feasibility and environmental sustainability. The project focuses on the development of processes for the recovery of fat, muscle protein and collagen.

Environment and Sustainability

Sustainable and resilient management of egg supply chains using Internet of Things

Dr. Armin Jabbarzadeh, École de technologie supérieure

Also covers: End of flock management, food safety, human nutrition and health, public policy and economics.

This research project is currently underway and an update will be provided in a future research summary.

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Visit **eggfarmers.ca** or contact us at **research@eggs.ca** for more information about Egg Farmers of Canada or our research program.

